Mission Directorate:	Science
Theme:	Astrophysics

Theme Overview

NASA's goal in astrophysics is to "Discover how the universe works, explore how the universe began and evolved, and search for Earth-like planets." Three broad scientific questions emanate from this goal. How do matter, energy, space, and time behave under the extraordinarily diverse conditions of the cosmos? How did the universe originate and evolve to produce the galaxies, stars, and planets we see today? What are the characteristics of planetary systems orbiting other stars, and do they harbor life?

The Astrophysics Theme addresses these questions via an integrated strategy incorporating a robust research and technology program, at least nine operating missions and six flight projects in various stages of planning and execution. This year's Astrophysics programmatic strategy is informed by the National Academies' recently released decadal survey titled "New Worlds, New Horizons in Astronomy and Astrophysics." The Astrophysics Theme represents a balance between bold new initiatives that open the universe to new discoveries and support for activities that strengthen the foundations of the research enterprise that are essential to the cycle of discovery.

The Astrophysics programs that support the integrated strategy are as follows:

- The Physics of the Cosmos (POCS) Program contains missions that explore the most fundamental and extreme physical conditions of the universe, from black holes and gravitational waves to dark matter and dark energy. These missions will enable the study of the building blocks of existence at the most basic level: matter, energy, space, and time;

- The Cosmic Origins Program comprises projects that enable the study of how galaxies, stars and planetary systems came into being, how they evolve, and ultimately how they end their lives;

- The Exoplanet Exploration Program contains missions that help search for Earth-like planets around other stars. These missions will explore the origin, structure, and evolution of other planetary systems as they search for other worlds;

- The Astrophysics Explorer Program conducts small principal investigator-led missions. Explorer missions are opportunities for innovative science that fill the scientific gaps between larger missions; and

- The Astrophysics Research Program prepares for the next generation of missions by supporting both theoretical research and applied technology investigations. These research activities use data from current missions and suborbital science investigations to advance NASA science goals, and provide hands-on workforce training of students and early-career scientists and engineers.

The budget for the James Webb Space Telescope (JWST) is now carried under its own Theme. This is consistent with management changes implemented in FY 2011 to improve management oversight and control over the project, following release of the Independent Comprehensive Review Panel's (ICRP) report in November 2010.

For more information, please see http://nasascience.nasa.gov/astrophysics.

Mission Directorate:	Science
Theme:	Astrophysics

FY 2012 Budget Request

Budget Authority ($ millions)	FY 2010	Ann CR. FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
FY 2012 President's Budget Request	**647.3**	**-**	**637.7**	**708.3**	**721.0**	**713.5**	**741.9**
Astrophysics Research	149.1	-	161.6	200.1	211.8	229.3	238.6
Cosmic Origins	225.3	-	219.7	219.4	209.9	195.2	184.5
Physics of the Cosmos	116.0	-	100.3	112.4	111.9	98.1	96.8
Exoplanet Exploration	43.4	-	48.2	65.5	63.6	62.1	69.8
Astrophysics Explorer	113.5	-	107.8	110.9	123.7	128.7	152.0

Note: The FY 2011 appropriation for NASA was not enacted at the time that the FY 2012 Request was prepared; therefore, NASA is operating under a Continuing Resolution (P.L. 111-242, as amended). Amounts in the "Ann. CR FY 2011" column reflect the annualized level provided by the Continuing Resolution.

In accordance with the President's proposal to implement a five-year non-security discretionary spending freeze, budget figures shown for years after FY 2012 are notional and do not represent policy. Funding decisions will be made on a year-by-year basis.

In FY 2012 through FY 2016, civil service labor and expenses (CSLE) funds are administered within a single consolidated account in each of the appropriations, and not allocated within the program amounts shown above. The allocation to each program is reflected in the summary budget table included in the beginning of this budget request, which provides a full cost view. In FY 2010 and FY 2011, amounts are presented in full cost.

Plans for FY 2012

Astrophysics Research

A Senior Review for operating missions will be conducted in the spring of 2012. This review involves a comparative evaluation of all Astrophysics operating missions and is conducted every two years. An independent expert panel evaluates the science output of each operating mission and makes recommendations as to which missions should receive funding for extended operation. A comparative evaluation for all Astrophysics mission data archives will be conducted in 2011.

The Astrophysics Research Program will continue to select peer-reviewed investigations for technology and detector development, suborbital missions, laboratory studies of astrophysical phenomena, theoretical studies and modeling of astrophysical phenomena targeted by past, current, and future missions, as well as limited ground-based observation in direct support of Astrophysics missions. A new program of postdoctoral fellowships will be initiated in FY 2012 for those working in astrophysics technology areas.

The Balloons project will support 16-20 suborbital flights, and will continue development of the new super-pressure balloon, which will be used to carry large scientific experiments to the brink of space for up to 100 days or more.

Cosmic Origins

Hubble Space Telescope will continue operations.

The Stratospheric Observatory For Infrared Astronomy (SOFIA) will continue to ramp up science flight hours and will complete open door flight testing.

The Herschel Space Observatory will continue prime operations.

Physics of the Cosmos

The Planck mission will continue prime operations. The Fermi Gamma-ray Space Telescope will remain in its prime operations phase, and the Chandra X-ray Observatory will continue on in extended operations.

Exoplanet Exploration

The Kepler mission will continue prime operations.

Large Binocular Telescope Interferometer (LBTI) scientific operations will start during FY 2011 and will continue during FY 2012.

Astrophysics Explorer

Astro-H (SXS) will be undergoing final assembly and test prior to shipment to Japan for final spacecraft integration and testing in early FY 2013.

The Nuclear Spectroscopic Telescope Array (NuSTAR) mission will launch in February 2012.

The Gravity and Extreme Magnetism (GEMS) mission will complete mission Critical Design Review (CDR).

Relevance

Relevance to national priorities, relevant fields, and customer needs:

NASA's Astrophysics Theme is guided by the National Aeronautics and Space Act of 1958 and subsequent legislation, the National Space Policy of the United States of America, and related policies that call on NASA to conduct space missions to advance scientific understanding of the universe. In doing so, NASA follows a long-standing tradition of establishing its science priorities through consultation with world-class experts via the National Academies' decadal survey process. The most recent astronomy and astrophysics decadal survey was released in August 2010. Astrophysics also receives tactical-level advice from the external science community via the Astrophysics Subcommittee of the NASA Advisory Council, and advice on cooperative activities from the Congressionally chartered, National Science Foundation (NSF)-managed Astronomy and Astrophysics Advisory Committee.

NASA enables research to understand the structure, content, and evolution of the universe. This research provides information about humankind's origins and fundamental physics that govern the behavior of matter, energy, space, and time. NASA leads the world in space-based research on the most compelling questions of modern physics, such as the nature of dark matter and dark energy, high-energy cosmic rays, tests of gravity and general relativity, and insight into cosmic inflation during the very early universe. NASA works proactively with the NSF and Department of Energy (DoE) in exploring the interfaces between astronomy and physics, and in the search for life in the universe.

Relevance to the NASA Mission and Strategic Goals:

Astrophysics research supports NASA's Strategic Goal 2, to "Expand scientific understanding of the Earth and the universe in which we live."

Relevance to education and public benefits:

Stunning images produced from operating Astrophysics missions continue to inspire the public, revealing the beauty of the universe and the science behind those images. NASA provides the tools to translate science for the classroom and other learning venues in ways that meet educator needs.

Hubble images are featured on the Space Telescope Science Institute's "Amazing Space" Web site, which provides curriculum support tools to classrooms in every state in the Nation. Spitzer's "Cool Cosmos" Web site offers explorations into the world of the infrared spectrum, and Chandra's Web site delivers authentic data sets to educators to enhance lessons by allowing students to use the same data that professional researchers use.

Several of NASA's Astrophysics missions have been featured in a traveling museum exhibit, "Alien Earths," which informs and inspires the public on critical questions related to the search for life elsewhere in the universe. The Astrophysics Exoplanet Exploration Program, in conjunction with the Astronomical Society of the Pacific, has sponsored the creation of "Night Sky Network" amateur astronomy clubs around the Nation. NASA also provides toolkits and professional development training to support these groups of space enthusiasts as they help strengthen the public understanding of astronomy and space science.

Mission Directorate:	Science
Theme:	Astrophysics

Performance

Performance Commitments:

Measure #	Description	Contributing Program (s)
Strategic Goal 2	**Expand scientific understanding of the Earth and the universe in which we live.**	
Outcome 2.4	**Discover how the universe works, explore how it began and evolved, and search for Earth-like planets.**	
Objective 2.4.1	**Improve understanding of the origin and destiny of the universe, and the nature of black holes, dark energy, dark matter, and gravity.**	
Performance Goal 2.4.1.1	***Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.***	
APG 2.4.1.1: AS-12-1	Demonstrate planned progress in understanding the origin and destiny of the universe, and the nature of black holes, dark energy, dark matter, and gravity. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	Multiple Programs
Performance Goal 2.4.1.2	***By 2015, launch at least one mission in support of this outcome.***	
APG 2.4.1.2: AS-12-2	Complete the Nuclear Spectroscopic Telescope Array (NuSTAR) Launch Readiness Review.	Astrophysics Explorer
Objective 2.4.2	**Improve understanding of the many phenomena and processes associated with galaxy, stellar, and planetary system formation and evolution from the earliest epochs to today.**	
Performance Goal 2.4.2.1	***Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.***	
APG 2.4.2.1: AS-12-3	Demonstrate planned progress in understanding the many phenomena and processes associated with galaxy, stellar, and planetary system formation and evolution from the earliest epochs to today. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	Multiple Programs
Performance Goal 2.4.2.3	***Develop and operate an airborne infrared astrophysics observatory.***	
APG 2.4.2.3: AS-12-4	Initiate the Stratospheric Observatory for Infrared Astronomy (SOFIA) Segment 3 Aircraft modifications and upgrades.	Cosmic Origins
Objective 2.4.3	**Generate a census of extra-solar planets and measure their properties.**	
Performance Goal 2.4.3.1	***Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.***	
APG 2.4.3.1: AS-12-5	Demonstrate planned progress in generating a census of extra-solar planets and measuring their properties. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	Multiple Programs

Uniform and Efficiency Measures:

Measure #	Description
Astrophysics Theme	
APG EFF: AS-12-6	Complete all development projects within 110 percent of the cost and schedule baseline.
APG EFF: AS-12-7	Deliver at least 90 percent of scheduled operating hours for all operations and research facilities.
APG EFF: AS-12-8	Peer-review and competitively award at least 95 percent, by budget, of research projects.
APG EFF: AS-12-9	Reduce time within which 80 percent of NASA Research Announcement (NRA) grants are awarded, from proposal due date to selection, by four percent per year, with a goal of 180 days.

Mission Directorate:	Science
Theme:	Astrophysics

Performance Achievement Highlights:

The High-Resolution Soft X-Ray Spectrometer (SXS) instrument for the Astro-H mission completed its Preliminary Design Review (PDR) on May 20, 2010. This was followed by the confirmation review on June 21, 2010. Astro-H SXS was approved to proceed into the development phase (Phase C).
A critical phase of SOFIA testing was successfully completed in FY 2010, when the SOFIA aircraft with the telescope installed was flight tested through a wide range of flight conditions and altitudes. No flight handling or acoustic anomalies were found in this flight testing, including up to the planned maximum flight altitude of 45,000 feet. Additionally, testing of telescope operations during this flight showed that telescope performance, including telescope pointing stability critical to astronomical observations, was as designed and required for astronomy. The first science instrument was integrated and flown in the SOFIA observatory in FY 2010, and obtained the "first light" image in May 2010.

Using data from the Fermi Gamma-ray Space Telescope, scientists have recently discovered a gigantic, mysterious structure in this galaxy. This feature looks like a pair of bubbles extending above and below the center of the galaxy. Fermi has also provided rare experimental evidence that space-time is as smooth as Einstein predicted.

The Hubble Space Telescope saw past the distance limit for galaxies and uncovered a primordial population of compact and ultra-blue galaxies that have never been seen before. At least one of the newly discovered galaxies lies beyond a redshift of 8.5, or 13.1 billion light-years distant. These discoveries means that the known time of formation of the first galaxies is less than 600 million years after the Big Bang, earlier than previously thought. The deep observations also demonstrate the progressive buildup of galaxies and provide further support for the hierarchical model of galaxy assembly. In this model, small objects accrete mass, or merge, to form bigger objects over a smooth and steady, but still dramatic, process of collision and agglomeration, and these small building blocks fuse into the larger galaxies known today.

The Herschel Space Observatory (Herschel) has made an unexpected discovery: a gaping hole in the clouds surrounding a batch of young stars. A cloud of bright reflective gas known to astronomers as NGC 1999 sits next to a black patch of sky. This patch looks black not because it is a dense pocket of gas but because it is truly empty space. Astronomers theorize that the hole must have been opened when the narrow jets of gas from some of the young stars in the region punctured the sheet of dust and gas that forms NGC 1999. The powerful radiation from a nearby adolescent star may also have helped to clear the hole. Whatever the precise chain of events, it could be an important glimpse into the way newborn stars rip apart their birth clouds.

NASA's Spitzer Space Telescope (Spitzer) has discovered something odd about a distant planet: the planet lacks methane, an ingredient common to many of the planets in Earth's solar system. The discovery brings astronomers one step closer to probing the atmospheres of distant planets the size of Earth. Eventually, a larger space telescope could use the same kind of technique to search smaller, Earth-like worlds for methane and other chemical signs of life, such as water, oxygen, and carbon dioxide. The methane-free planet, called GJ 436b, is about the size of Neptune, making it the smallest distant planet that any telescope has successfully analyzed.

Mission Directorate:	Science
Theme:	Astrophysics

Independent Reviews:

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	Senior Review Panel	04/2010	Comparative review of missions currently in operation to rank the scientific merit of their extended mission proposals. In the most recent review, Planck and Chandra missions ranked highest, while Integral and WISE ranked lowest. Results and the report can be found at http://science.nasa.gov/astrophysics/2010-senior-review/.	04/2012
Performance	National Research Council	05/2006	Congressionally mandated review by the National Academies. The resulting letter report found that "It is vital that the strong, balanced science program in astronomy and astrophysics that has served the Nation so well continue to be sustained as any new policy is implemented."	TBD
Relevance	National Research Council	08/2010	Decadal survey to set science and mission priorities for NASA's Astrophysics Program. The report, "New Worlds, New Horizons," concluded that NASA's Astrophysics Program is properly structured to address the science questions identified by the science community, and provided a prioritized list of future Astrophysics missions.	08/2020

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Research

FY 2012 Budget Request

Budget Authority ($ millions)	FY 2010	Ann CR. FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
FY 2012 President's Budget Request	**149.1**	**-**	**161.6**	**200.1**	**211.8**	**229.3**	**238.6**
Astrophysics Research and Analysis	59.6	-	64.3	82.8	83.9	85.1	88.0
Balloon Project	28.2	-	29.3	32.8	33.6	34.1	35.3
Other Missions and Data Analysis	61.3	-	67.9	84.5	94.3	110.1	115.4

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Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Research

Program Overview

The Astrophysics Research Program supports the early development of new technologies for future missions and suborbital flights of experimental payloads on balloons and sounding rockets. It provides funding to analyze the data from NASA missions to understand astronomical events such as the explosion of a star, the birth of a distant galaxy, or the motion of planets around their parent stars. The program also supports basic research for scientists to work out the consequences of their theories, and to understand how they can best use data from NASA missions to develop new knowledge about the cosmos.

The first step in developing new technologies for future NASA missions is to show that the technology can work in the laboratory. A new type of scientific instrument is often flown first on a high-altitude balloon mission, or on a sounding rocket flight that takes it briefly outside Earth's atmosphere. Instruments for balloons and sounding rockets are not as costly as those for an orbital mission, and they can be built quickly to respond to unexpected opportunities. The equipment is usually retrieved after the flightso that novel instruments can be tested, improved, and flown again. These suborbital flights are important in training the next generation of scientists and engineers to compete better in the 21st century, and to maintain U.S. leadership in science, engineering, and technology.

NASA's policy is to make the data from its space science missions available freely to everyone. These data are archived at a few consolidated astrophysics data centers, from which users can download them. The centers also provide tools that enable users to combine different sets of data to examine how the appearance of the sky changes when it is observed with different kinds of light. For example, the remnant of an exploding star (a supernova) looks very different in pictures taken in visible light and in X-rays. More information can be found at http://nasascience.nasa.gov/astrophysics/astrophysics-data-centers.

Over the years, NASA has invested heavily in the development and execution of an extensive array of space astrophysics missions. The magnitude and scope of the archival data from those missions enables science that transcends traditional wavelength regimes and allows researchers to answer questions that would be difficult, if not impossible, to address through an individual observing program. To capitalize on this invaluable asset and enhance the scientific return on NASA mission investments, the Astrophysics Data Analysis Program (ADAP) provides support for investigations whose focus is on the analysis of archival data from NASA space astrophysics missions.

For more information on the Astrophysics Research Program, please see http://nasascience.nasa.gov/researchers/sara/.

Plans For FY 2012

The Astrophysics Research Program has made changes to address the need for technology development, as indicated by the 2010 decadal survey recommendations. Funding has been added to the Astrophysics Research and Enabling Technology program (APRET, formerly APRA, now renamed to indicate its focus more accurately) to enhance development of optics, detectors, and other key technologies, including addressing mid-technology readiness gap identified in the decadal survey. Another addition is to initiate a new postdoctoral fellowship for those working in Astrophysics instrumentation and technology areas. This fellowship would be analogous to the Hubble, Einstein, and Sagan fellowships but is funded for five years since technology development takes longer to complete. Three fellows would be selected each year and would receive up to $0.5 million for equipment purchases.

The decadal survey recommended an increase in suborbital flights and a substantial increase to both the Astrophysics Theory program, and Laboratory Astrophysics funding. The Astrophysics Research Program plans to increase the budget in these two areas significantly over the budget horizon, to best respond to the decadal recommendations.

In 2012, the Balloon program will conduct 16 to 20 flights, including two foreign campaigns. These will follow the corrective action plan developed to respond to the recommendations of the Mishap Investigation Board for the 2010 launch mishap in Australia. In particular, an independent Operations Safety Officer will be on-site throughout each campaign, and a Range Safety Officer will have the authority to terminate each launch at any stage.

In 2012, in addition to the individual-investigator proposals that represent the core of the program, a new component will be introduced to the Laboratory Astrophysics program--consortium awards to support extended, multi-disciplinary teams of scientists that will address grand challenges in astrophysics. Solicitations will address wide-ranging topics that impact the entire field of astrophysics and which are sufficiently broad that they cannot be effectively addressed by individual investigators working independently. In 2012, NASA will solicit consortium proposals that address the grand challenge of understanding carbon and carbon-rich compounds in the universe.

In 2012, the Spitzer Heritage Archive will be transferred into the NASA InfraRed Processing and Analysis Center (IPAC) InfraRed Science Archive (IRSA). All data collected by the Spitzer cryogenic mission will be distributed through IRSA.

In addition to ongoing awards, the Education and Public Outreach project will competitively select approximately 40 new proposals for small awards averaging $10,000 a year, and approximately 15 new proposals for mid-range awards averaging $160,000 a year.

Project Descriptions and Explanation of Changes

Astrophysics Research & Analysis (R&A)

This project solicits basic research proposals for investigations that are relevant to NASA's programs in astronomy and astrophysics, over the entire range of photon energies, gravitational waves, and particles of cosmic origin. The largest element of the R&A project is the Astrophysics Research and Enabling Technology (APRET) program. APRET supports research that addresses the best possible state-of-the-art detector and technology development for instruments that may be proposed as candidate experiments for future space flight opportunities; science and technology investigations with instruments flown on suborbital sounding rockets, stratospheric balloons, or other platforms; and laboratory research and (with restrictions) ground-based observations that are directly applicable to space astrophysics missions.

The Astrophysics Theory Program (ATP) supports efforts to develop the basic theory for NASA's space astrophysics programs. Astrophysics Theory topics include: star formation, supernovae and gamma-ray bursts, large-scale cosmic structures and dark matter, dark energy and the cosmic microwave background, and gravitational wave astronomy.

The 2010 decadal survey recommended substantially more opportunities for suborbital flights, and increased support for Laboratory Astrophysics and the Astrophysics Theory program. The Astrophysics Research Program plans significantly increased funding for technology development and suborbital payloads, and for both Laboratory Astrophysics and the Theory programs, including a new component for large computational networks.

All R&A grants selected for funding by the Astrophysics Theme are broadly competed through NASA's Research Opportunities in Space and Earth Sciences. Grant proposals must relate directly to both Agency and theme goals and objectives. All proposals are peer-reviewed by scientists and technologists from a mix of disciplines and are selected based upon merit.

Balloons

The Wallops Flight Facility manages the NASA Balloon project. The project offers inexpensive, high-altitude flight opportunities for scientists to conduct research and test new technologies prior to space flight application. Balloon experiments cover a wide range of disciplines in astrophysics, solar and heliospheric physics, as well as Earth upper-atmosphere chemistry. Observations from balloons have even detected echoes of the Big Bang, and probed the earliest galaxies. The Balloon project continues to work to increase balloon size and enhance capabilities, including an accurate pointing system to allow detection of planets around other stars, and a super-pressure balloon to allow much longer flight periods at high altitude.

The Columbia Scientific Balloon Facility (CSBF) provides launch services for large (400 feet diameter), unmanned, high-altitude (120,000 feet) research balloons, tracking. On behalf of NASA Centers and universities all over the world, CSBF recovers the scientific experiments suspended beneath the balloons. Domestic flights are launched from Fort Sumner, New Mexico, and Palestine, Texas. Mid-latitude flights are launched from Australia. Balloons operating above the polar regions are deployed from Antarctica and Sweden.

Additional funding has been added in FY 2013 to increase the balloon flight rate and to continue development of super-pressure ballooning.

Other Missions and Data Analysis

Included in this line item are:

- Astrophysics Data Curation and Archival Research (ADCAR): The Astrophysics Theme has established an archive structure beyond the scope of individual missions, to receive data and make them accessible by creating an ensemble of primarily wavelength-specific astrophysics archives. After the completion of a mission, all archive activities are taken over by the relevant active multi-mission archive. ADCAR covers the activities of the Astrophysics Data Centers and NASA's participation in the Virtual Astronomical Observatory. Priorities in FY 2012 and beyond will incorporate the recommendations of the Archival Senior Review that will take place in May 2011. For more information see http://nasascience.nasa.gov/astrophysics/astrophysics-data-centers.

- Astrophysics Data Analysis Program (ADAP): ADAP solicits research whose primary emphasis is the analysis of NASA space astrophysics data that are archived in the public domain at one of NASA's Astrophysics Data Centers. Recent years have seen a dramatic growth in both the size and scope of the archival astronomical data available to ADAP researchers, including data from such major strategic missions as Spitzer and Kepler. These data are already bought and paid for. Every dollar invested in archival research using these data bring additional value to the Nation's investment in that NASA mission. The steady increase in the program budget in coming years is designed to ensure continued effective exploitation of this tremendous scientific resource as data holdings continue to grow.

- Astrophysics Senior Review: This funding will extend the life of operating missions. The Senior Review is conducted every two years as a comparative evaluation of all operating missions (both Explorers and strategic missions) that are in or are about to enter an extended phase past their prime operations phase. A ranking based on science output determines which missions will continue to receive funding for extended operations. Additional funding has been added to ensure a robust suite of extended missions in FY 2013 and beyond.

- Keck Single Aperture (KSA): KSA manages NASA time on the Keck Telescopes by issuing the proposal solicitation, conducting the peer review, communicating selections for investigations, and providing support to observers. KSA also manages the Keck archives for the High Resolution Echelle Spectrometer (HIRES), and the Near Infrared Spectrometer (NIRSPEC) instruments. The HIRES primarily measures the radial velocity data used to find and characterize exoplanets, and NIRSPEC is a general-purpose near-infrared spectrometer widely used by Keck observers.

- Directorate Support, Space Science: This project funds Agency-level services provided to the Science Mission Directorate (SMD). These services include Defense Contract Audit Service contract administration, Defense Contract Audit Agency audit services, and NASA Contract Assurance Services for all of SMD's projects.

- Education and Public Outreach: This project supports development and dissemination of new educational and outreach products based on SMD science discoveries, through competitively selected awards ranging from $10,000-$160,000 per year. Opportunities are provided for students and educators, citizen scientists, and the public to engage in authentic experiences working with NASA data and NASA research communities. The project also supports four science education and public outreach forums that foster engagement of the target audiences through interactive communication and public feedback.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Research

Program Management

SMD provides program management, with individual projects managed at the Goddard Space Flight Center (GSFC) and the Jet Propulsion Laboratory (JPL).

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	Mission Senior Review Panel	4/2010	A comparative evaluation of all the Astrophysics operating missions. A report ranking the operating missions was released.	4/2012
Quality	Archival Senior Review Panel	05/2008	Comparative review of the efficiency and cost effectiveness of the archives. A report ranking the archives was released.	05/2011

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins

FY 2012 Budget Request

Budget Authority ($ millions)	FY 2010	Ann CR. FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
FY 2012 President's Budget Request	**225.3**	**-**	**219.7**	**219.4**	**209.9**	**195.2**	**184.5**
Hubble Space Telescope (HST)	100.8	-	94.0	93.4	93.1	88.8	84.5
Stratospheric Observatory for Infrared Astronomy (SOFIA)	73.6	-	71.4	73.3	77.2	77.4	75.0
Other Missions And Data Analysis	50.9	-	54.4	52.7	39.6	28.9	25.0

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Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins

Program Overview

The Cosmic Origins Program seeks to answer the fundamental question "how did we get here?" by investigating the evolution of the universe and its components, from the cosmic Big Bang to the present. Topics in Cosmic Origins research include the following: When did the first stars and galaxies form? How are stars and planets created? When did the universe first create elements critical for life? How do galaxies, stars and planets change with cosmic time?

Missions within Cosmic Origins have and continue to make important advances on these fronts. Celebrating more than 20 years of operation, the Hubble Space Telescope continues to inspire youth through its exploration of the universe. Hubble images have enabled important discoveries in areas as diverse as the violent and ever-evolving state of the solar system, observing new asteroid collisions, and the universe-wide "warming" that occurred 11 billion years ago when fierce blasts of radiation from voracious black holes stunted the growth of some small galaxies for a stretch of 500 million years. Through its annual call for observing proposals and online data archive, Hubble will serve thousands of astronomers with data over the full scope of Cosmic Origins questions. In addition, NASA's partnership with European Space Agency (ESA) on Herschel, the newest operating Cosmic Origins telescope, has yielded a critical finding about how water is formed in space. Analysis of Herschel data has revealed that ultraviolet starlight is the key ingredient for making water in space. Many more discoveries are expected over the next three years until Herschel's helium cryostat is depleted.

The SOFIA airborne telescope is continuing its early science flights this year and promises to enable optical through far-infrared astronomy for decades. SOFIA is uniquely capable of studying the chemistry of the universe. It will help scientists study the chemical processes in star forming regions within this galaxy. SOFIA's far-infrared instruments will also study distant galaxies. Importantly, SOFIA will allow instrument upgrades through the coming years to take advantage of new technologies and new science aims.

For more information, please see http://nasascience.nasa.gov/about-us/smd-programs/cosmicorigins.

Plans For FY 2012

Hubble Space Telescope (HST) will continue to support spacecraft and science operations, as well as robust Guest Observer grants.

SOFIA will continue to ramp up science flight hours and will complete open door flight testing. The second generation of observatory instruments will be selected through a competitive Announcement of Opportunity.
Spitzer and Herschel will continue operations.

Technology investments will support Hubble de-orbit studies, advanced infrared detectors, technology for possible future SOFIA instruments, and the definition of a future ultraviolet (UV)-optical space capability.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins

Project Descriptions and Explanation of Changes

James Webb Space Telescope

This project has been moved to its own theme within the Science Mission Directorate. See the JWST Theme pages for detailed project information.

Hubble Space Telescope (HST)

HHST launched in FY 1990 and is currently in an extended operations phase. The fourth servicing mission (SM4), completed in FY 2009, added new batteries, gyros and instruments to extend its life even further into the future. One of NASA's most successful and long-lasting science missions, HST has beamed hundreds of thousands of images back to Earth, shedding light on many of the great mysteries of astronomy. Its gaze has helped scientists determine the age of the universe, the identity of quasars, and the existence of dark energy. Development of the capability to de-orbit safely HST after its mission has concluded is underway within the Cosmic Origins Program. The timing for this activity will be determined by the status of the observatory and the orbital conditions that would drive an uncontrolled reentry. Funding in the HST budget in FY 2012 and out will support mission operations, systems engineering, software maintenance, ground systems support, and Guest Observer science grants. Efforts to reduce the costs of mission operations will continue, and Hubble will enter the Senior Review process in 2012.

Stratospheric Observatory for Infrared Astronomy (SOFIA)

SOFIA, currently in development, is a Boeing 747SP airborne observatory with a 2.5-meter reflecting telescope that will enable the study of the universe in the infrared spectrum. Besides this contribution to science progress, SOFIA technologies will be a major contributor to the development of new observational techniques, new instrumentation and in the education of young scientists and teachers in the discipline of infrared astronomy. The project will be at full operational capability in CY 2014. The SOFIA budget in FY 2012 and out reflects investments in the new instrument selection schedule and science hours and funds risk reduction activities. See the project page of this document for more detail.

Other Missions and Data Analysis

Included in this line item are:

- The Spitzer Space Telescope, now in extended operations, is an infrared telescope utilizing two channels of the Infrared Array Camera instrument to study the atmosphere of exoplanets, looking for the earliest clusters of galaxies, near Earth asteroids and providing a 360 degree map of the galaxy. Spitzer completed its cryogenic mission in FY 2009, and warm operations have been extended through FY 2013, per the recommendation of the 2010 Senior Review but at reduced costs.

- The Herschel Space Observatory is a collaborative mission with ESA and launched on May 14, 2009. It has the largest single mirror ever built for a space telescope and it will collect long-wavelength radiation from some of the coldest and most distant objects in the universe. NASA has contributed to instruments onboard Herschel and will also host U.S. astronomer access to data through the NASA Herschel Science Center.

- Cosmic Origins Supporting Research and Technology supports Hubble fellowships and program-specific research and early technology development efforts. Budget increases have been made in FY 2013 and out to support the study of a future UV-optical space capability and wide-field infrared imaging and spectroscopy, particularly in the area of advanced detector technology, in response to the decadal survey recommendations.

- Cosmic Origins Future Missions funding has been moved to support JWST and future Explorer selections.

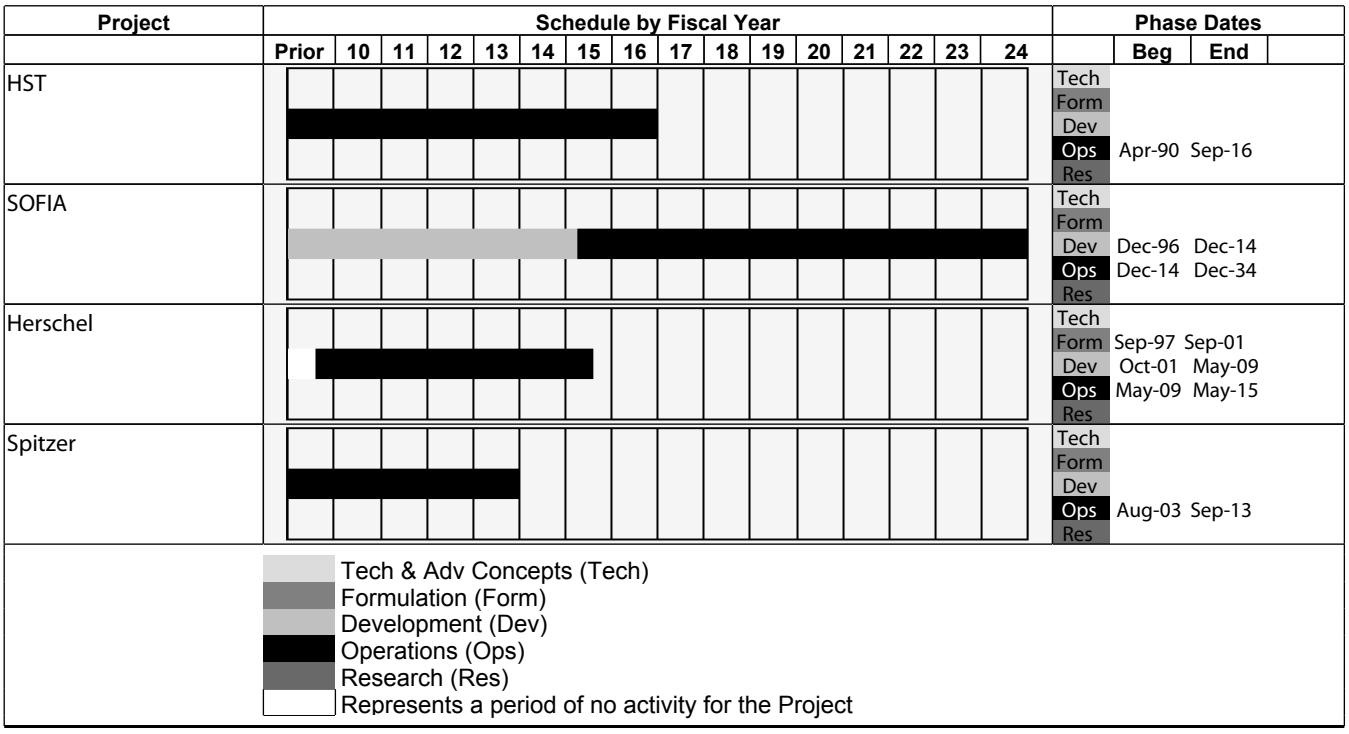
- Cosmic Origins Program management provides programmatic, technical, and business management, as well as program science leadership and coordination for education and public outreach products and services. Funding has been increased to provide more robust program management of missions in development and formulation.

Program Commitments

Commitment/Output FY 2012	Program/Project	Changes from FY 2011 PB Request
Initiate the Stratospheric Observatory for Infrared Astronomy (SOFIA) Segment 3 Aircraft modifications and upgrades.	SOFIA	

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins

Implementation Schedule



Program Management

Cosmic Origins project management responsibility is as follows:

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
HST	GSFC	GSFC	ESA
SOFIA	DFRC	DFRC, ARC	German Space Agency (DLR)
Spitzer	JPL	JPL	None
Herschel	JPL	JPL	ESA

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins

Acquisition Strategy

The HST Space Telescope Science Institute (STScI) is run under contract to NASA by the Association of Universities for Research in Astronomy. STScI is responsible for the science program selection, planning, scheduling, science data processing and archiving, grant administration, and public outreach activities for HST. The basic period of the HST STScI contract with AURA ended on April 30, 2010, with the first of two contract options being exercised on May 1, 2010 and running through April 30, 2013.

The HST mission operations functions (i.e., flight operations, observatory engineering analysis, and flight and ground software development) are performed under a separate contract. The HST mission operations contract will expire on June 30, 2011. A new five-year HST Missions Operations contract will be awarded to Lockheed Martin on July 1, 2011.

The second generation of instruments for the SOFIA observatory will be solicited through a NASA Announcement of Opportunity. The solicitation will be released in FY 2011 with selections planned for early FY 2012.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	Stratospheric Observatory for Infrared Astronomy (SOFIA)

FY 2012 Budget Request

Budget Authority ($ millions)	Prior	FY 2010	Ann CR. FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
FY 2012 President's Budget Request	**737.5**	**73.6**	**-**	**71.4**	**73.3**	**77.2**	**77.4**	**75.0**

Note: For the FY 2012 Budget Request, project life cycle estimates, required to meet the requirements of section 103 of the NASA Authorization Act of 2005 (P.L. 109-155; 42 U.S.C. 16613), have been consolidated in the Management and Performance Section of this document. This consolidation provides for a comparative analysis across projects, and the inclusion of corrective action plans for the projects that have exceeded their original baseline estimates by greater than fifteen percent.

The FY 2011 appropriation for NASA was not enacted at the time that the FY 2012 Request was prepared; therefore, NASA is operating under a Continuing Resolution (P.L. 111-242, as amended). Amounts in the "Ann. CR FY 2011" column reflect the annualized level provided by the Continuing Resolution.

In accordance with the President's proposal to implement a five-year non-security discretionary spending freeze, budget figures shown for years after FY 2012 are notional and do not represent policy. Funding decisions will be made on a year-by-year basis.

In FY 2012 through FY 2016, civil service labor and expenses (CSLE) funds are administered within a single consolidated account in each of the appropriations, and not allocated within the project amounts shown above. The allocation to each project is reflected in the summary budget table included in the beginning of this budget request, which provides a full cost view. In FY 2010 and FY 2011, amounts are presented in full cost.

Explanation of Project Changes

Additional funds were added to the development budget to preserve the new instrument selection schedule and science hours and to fund risk reduction activities. The operations budget was decreased due to risk reduction activities previously planned for operations being moved into development. The SOFIA milestone Full Operational Capability (FOC) has been redefined as the capability to provide full science operational capability with four available instruments. Outyear budgets reflect NASA's intention to increase the efficiency of the science operations after FOC has been achieved.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	Stratospheric Observatory for Infrared Astronomy (SOFIA)

Project Purpose

NASA is developing SOFIA as a world-class airborne observatory that will complement the Hubble, Spitzer, Herschel and James Webb space telescopes, and major Earth-based telescopes. SOFIA features a German-built 2.5 meter (100-inch) diameter far-infrared telescope weighing 20 tons, and mounted in the rear fuselage of a highly modified Boeing 747SP aircraft.

The SOFIA mission will study many different kinds of astronomical objects and phenomena, including: star birth and death, formation of new solar systems, identification of complex molecules in space, planets, comets and asteroids in this solar system, nebulae and dust in galaxies (i.e., ecosystems of galaxies), and black holes at the center of galaxies. The infrared light of these objects is only partially visible from the ground due to water vapor in Earth's atmosphere. However, at high altitudes, the influence of water vapor is negligible, allowing better observation of these astronomical objects.

SOFIA'S reflecting telescope provides astronomers with access to the visible, infrared and sub-millimeter spectrum, with optimized performance in the mid-infrared to sub-millimeter range. During its 20-year expected lifetime, SOFIA will be capable of enabling "Great Observatory" class astronomical science.

SOFIA will be NASA's only far-infrared mission, as Spitzer cryogens have been depleted and Herschel's cryogens will be exhausted by 2013. It is the only mid-infrared mission until JWST becomes operational. SOFIA's ability to reconfigure and flexibility ensures the integration of cutting-edge technology and the ability to address emerging scientific questions. For more information, please see http://www.nasa.gov/mission_pages/SOFIA/index.html.

Project Parameters

SOFIA was designed as a highly modified Boeing 747SP aircraft with a large open-port cavity aft of the wings, housing a 2.5-meter telescope optimized for infrared andsub-millimeter wavelength astronomy. SOFIA will operate in flight at 41,000 feet, and at FOC will have four instruments, with additional instruments available after FOC. SOFIA will ramp up to 960 science hours per year, and flights will last six to eight hours on average.

Germany has provided the telescope assembly and assists with mission operations. NASA has provided, refurbished, and modified the airplane, and provides the Science Operations Center.

The U.S.-developed instruments include High-speed Imaging Photometer for Occultation (HIPO), First Light Infrared Test Experiment CAMera (FLITECAM), Faint Object InfrRed CAmera for the SOFIA Telescope (FORCAST), Echelon-Cross-Echelle Spectrograph (EXES), and High-resolution Airborne Wideband Camera (HAWC). The two German instruments are the German Receiver for Astronomy at Terahetz Frequencies (GREAT) and Field Imaging Far-Infrared Line Spectrometer (FIFI LS).

Technology investments for possible future SOFIA instrumentation are made through the Cosmic Origins Supporting Research and Technology program.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	Stratospheric Observatory for Infrared Astronomy (SOFIA)

Project Commitments

SOFIA initiated science observations in December 2011 with the FORCAST instrument. Designed to work for 20 years, SOFIA will reach FOC as an airborne observatory in December 2014.

Project Element	Provider	Description	FY 2011 PB Request	FY 2012 PB Request
Platform	DFRC/L3/MPC	Refurbished Boeing 747SP modified to accommodate telescope	Same	Same
Science Operations Center	ARC/USRA	Science Operations Center will schedule observations, and manage data acquisition and processing	Same	Same
Telescope	Germany (DLR)	2.5m diameter, dual mirror	Same	Same
Flight Operations	DFRC/CSC DyneCorp	Flight crew, maintenance, and fuel	Same	Same
HIPO	Lowell Observatory	Simultaneous high-speed time-resolved imaging photometry at two optical wavelengths	Same	Same
FLITECAM	UCLA	Large field-of-view, narrow- and broad-band photometric imaging and low-resolution spectroscopy from 1 to 5.5 µm	Same	Same
FORCAST	Cornell University	Large field-of-view, narrow- and broad-band photometric imaging and moderate-resolution spectroscopy from 4 to 42 µm	Same	Same
EXES	ARC	Echelon Spectrometer, 5-28 microns R=105, 104, or 3000	Same	Same
HAWC	University of Chicago	Far-Infrared Bolometer Camera, 50-240 microns	Same	Same
GREAT	Germany (DLR)	Infrared heterodyne spectrometer, 60-200 microns	Same	Same
FIFI LS	Germany (DLR)	Imaging spectrometer, 42-210 microns	Same	Same

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	Stratospheric Observatory for Infrared Astronomy (SOFIA)

Schedule Commitments

The development and test plan has been modified to enable earlier science observations by the science community, making it concurrent with the late phases of aircraft flight testing. Initial science observations with a subset of science instruments began in December 2011. Completion of the remaining science instruments and refinement of telescope performance will enable FOC in December 2014.

Milestone Name	Confirmation Baseline	FY 2011 PB Request	FY 2012 PB Request
Development			
First Flight	2000	2007	2007
First Science (Early Science)	N/A	2010	2011
FOC	N/A	2014	2014

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	Stratospheric Observatory for Infrared Astronomy (SOFIA)

Project Management

The overall SOFIA project and SOFIA airborne system are managed by Dryden Flight Research Center (DFRC). SOFIA science is managed by Ames Research Center (ARC).

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Platform	DFRC	DFRC	Germany - DLR/DSI
Science	ARC	None	Germany - DLR/DSI
Mission Operations and Data Analysis	ARC	None	Germany - DLR/DSI
Instruments	ARC	None	Germany - DLR/DSI

Acquisition Strategy

DFRC manages the program and the platform project (airframe and telescope). DFRC is working with L-3 Communications (Waco, Texas), and MPC Products Corporation (Skokie, Illinois) to support the completion of the development, integration, and test of the airborne platform system. L-3 modified the Boeing 747SP aircraft to install the telescope provided by Germany (DLR/DSI). MPC is developing the telescope cavity door drive system. DFRC is also working with CSC DynCorp (El Segundo, California) to provide aircraft maintenance support.

ARC manages the science project. ARC is working with University Space Research Association (USRA) (Columbia, Maryland) for the SOFIA science planning, ground science facilities, science instrument and technology development, and education and public outreach.

Second generation and later instruments will be solicited through an open competition using a NASA Announcement of Opportunity.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	Standing Review Board	4/2010	Early science project review. The board determined that plan for early science had merit.	4/2012

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Loss of science community and DLR support due to late science	Loss of science community support due to delays in science continues to be a concern.	Report program accomplishments as they occur to keep the science community engaged and supportive. Reaction to recent program successes, including the first light accomplishment, has been very positive.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Physics of the Cosmos

FY 2012 Budget Request

Budget Authority ($ millions)	FY 2010	Ann CR. FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
FY 2012 President's Budget Request	**116.0**	**-**	**100.3**	**112.4**	**111.9**	**98.1**	**96.8**
Other Missions and Data Analysis	116.0	-	100.3	112.4	111.9	98.1	96.8

Note:
The FY 2011 appropriation for NASA was not enacted at the time that the FY 2012 Request was prepared; therefore, NASA is operating under a Continuing Resolution (P.L. 111-242, as amended). Amounts in the "Ann. CR FY 2011" column reflect the annualized level provided by the Continuing Resolution.

In accordance with the President's proposal to implement a five-year non-security discretionary spending freeze, budget figures shown for years after FY 2012 are notional and do not represent policy. Funding decisions will be made on a year-by-year basis.

In FY 2012 through FY 2016, civil service labor and expenses (CSLE) funds are administered within a single consolidated account in each of the appropriations, and not allocated within the project amounts shown above. The allocation to each project is reflected in the summary budget table included in the beginning of this budget request, which provides a full cost view. In FY 2010 and FY 2011, amounts are presented in full cost.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Physics of the Cosmos

Program Overview

The universe can be viewed as a laboratory that enables scientists to study some of the most profound questions at the intersection of physics and astronomy. How did the universe begin? What is the universe composed of, and what is its ultimate fate? What are the fundamental laws that govern the workings of space, time, matter, and energy? The POCS Program is aimed at addressing these questions by exploring the most extreme physical conditions of the universe including black holes, dark energy, and the early moments of its creation.

The operating missions within the POCS Program are just beginning to provide answers to these questions. The Fermi mission is searching for signs of new laws of physics and what composes the mysterious dark matter and will help explain how black holes accelerate immense jets of material to nearly the speed of light. Following in the footsteps of the very successful The Wilkinson Microwave Anisotropy Probe (WMAP) mission, Planck is observing the earliest moments of the universe and is providing a high-resolution map of the cosmic microwave background. XMM-Newton has helped scientists solve a number of cosmic mysteries, ranging from enigmatic black holes to the origins of the universe itself. Chandra continues to reveal new details of celestial X-ray phenomena such as the collisions of galaxies that directly detect the presence of dark matter, and has unveiled a population of faint, obscured massive black holes that may provide the early seeds for galaxy formation and growth.

The POCS Program will actively pursue opportunities for vigorous mission partnership and technology investments, following the recommendations of the 2010 National Academies astronomy and astrophysics decadal survey. Also following the recommendations of the decadal survey, the POCS Program looks towards the next decade by continuing to support technology development for several highly ranked missions. Leading this charge is the Laser Interferometer Space Antenna (LISA) that will observe the universe using the completely unexplored spectrum of gravitational waves. Near-term support for LISA focuses on the NASA technology demonstrator payload ST-7 on the ESA-led LISA Pathfinder mission. Also highly recommended is support for the International X-ray Observatory (IXO) that will observe regions near the surfaces of super massive black holes. Finally, this program will develop the most promising technology to detect the imprint of gravitational waves on the cosmic microwave background produced during the first few moments of the universe. For more information see: http://nasascience.nasa.gov/about-us/smd-programs/physics-of-the-cosmos.

Plans For FY 2012

In FY 2012, funds allocated under the Exoplanet Exploration Program, discussed below, will support the early planning of the Wide Field Infrared Survey Telescope (WFIRST), the top priority Large mission of the New Worlds New Horizons decadal survey. Understanding the nature of dark energy, using a variety of investigation techniques, is among WFIRST's recommended science objectives. In parallel, NASA is exploring a potential partnership with the European Space Agency (ESA) on its proposed Euclid dark energy mission that is currently competing in their Cosmic Vision process. NASA will consider partnerships with ESA that are in line with Option B (A Joint WFIRST/Euclid Mission) from the National Research Council's "Report of the Panel on Implementing Recommendations from the New Worlds, New Horizons Decadal Survey."
In FY 2012, Planck will be in full science operations. Planck will complete the first full-sky survey of the cosmic microwave background and will process the science data to produce the first Planck science results. Then the second full-sky survey will provide critical refinement of cosmic microwave background and further science results.

The Fermi Gamma Ray Space Telescope will continue its prime operations phase, making observations selected by peer review.

Chandra will continue extended mission operations, making observations selected by peer review.

Technology funding will support technical studies on the LISA and IXO mission concepts as well as cosmic inflation probe concepts, as recommended by the decadal survey.

NASA will continue to support the spacecraft integration and testing of the ST-7 Disturbance Reduction System on the ESA-led LISA Pathfinder mission in preparation for a 2013 launch.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Physics of the Cosmos

Included in this line item are:

- Planck, launched in May 2009, is an ESA-led mission with substantial NASA contributions. It will reveal the geometry and contents of the universe, how the universe grew immediately after its birth, and how the stage was set for the universe to evolve into structures that are seen today, such as galaxies. It will provide an order of magnitude increase in precision in its measurement of the cosmic microwave background.

- Fermi Gamma-ray Space Telescope is a joint NASA/DoE mission formerly called Gamma-ray Large Area Space Telescope. Fermi launched in June 2008 and is currently in operational phase. It is designed to detect the highest energy gamma-rays ever measured in a space-based mission and is providing a full-sky map filled with thousands of new and previously known gamma-ray sources, increasing the current tally by orders of magnitude.

- Chandra, a flagship X-ray observatory currently in extended operations, has allowed scientists to image complex systems in exquisite detail, and to determine the positions of thousands of distant X-ray sources. Chandra has also provided unique information on diverse subjects ranging from the presence and amount of dark matter in the universe to phenomena occurring near the horizons of black holes. Outyear budget planning reflects NASA's efforts to maximize efficiency while achieving reduced operations costs.

- POCS Supporting Research and Technology (SR&T) supports Einstein Fellowships and program-specific research and early technology development effort including:

  - Responsibility for the ST-7 project (previously under the Heliophysics New Millennium Program) has been transferred to the POCS Program and additional funding has been provided to accommodate the launch slip to the European Space Agency (ESA) LISA Pathfinder mission, now scheduled for 2013. The ST-7 project will validate system-level technologies required for use on future gravity-wave and formation flying missions, such as LISA.

  -Early technical and mission concept activities that will continue on the Laser Interferometer Space Antenna (LISA), a joint mission with the ESA. LISA will provide a first view of the gravitational radiation spectrum from space providing a new and uniquely powerful probe of the extremes of space-time.

  -Early technical and mission concept activities will continue on the IXO, an X-ray observatory with joint participation from NASA, ESA and the Japan Aerospace Exploration Agency (JAXA). Science objectives are the study of black holes and matter under extreme conditions, and the life cycles of matter and energy in the universe.

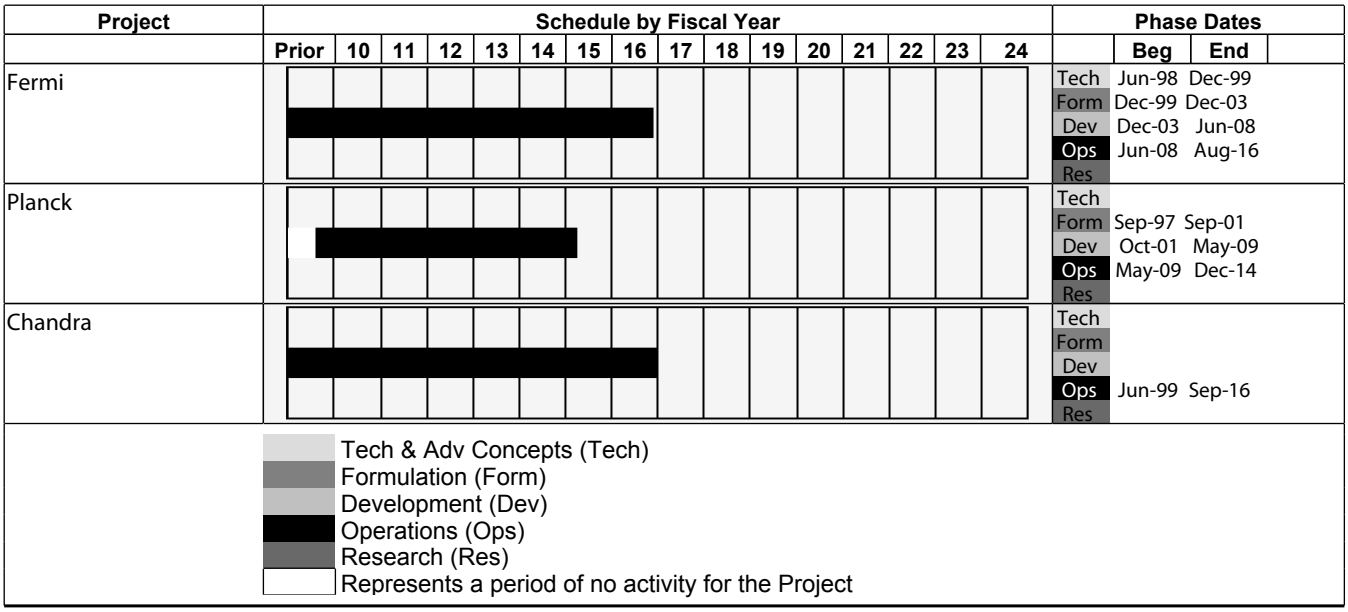
  -Early technical studies for cosmic inflation probe technology and mission concepts, as recommended in the 2010 decadal survey.

- POCS Program management provides programmatic, technical, and business management, as well as program science leadership and coordination for education and public outreach products and services. Funding has been increased to provide more robust program management of missions in development and formulation.

- POCS Future Missions funding has been partially moved to support future Astrophysics Explorer missions and the POCS SR&T activities.

- Support for the Joint Dark Energy mission has been terminated and redirected to other activities recommended by the 2010 decadal survey.

Implementation Schedule



Program Management

GSFC has program management responsibility. Project management is as follows:

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Fermi	GSFC	GSFC	DOE, Japan, Italy, France, Sweden, and Germany
Planck (Instrumentation)	JPL	JPL	ESA
Chandra	MSFC	MSFC	None

Acquisition Strategy

No competitive acquisitions are planned at this time.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Exoplanet Exploration

FY 2012 Budget Request

Budget Authority ($ millions)	FY 2010	Ann CR. FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
FY 2012 President's Budget Request	**43.4**	**-**	**48.2**	**65.5**	**63.6**	**62.1**	**69.8**
Other Missions and Data Analysis	43.4	-	48.2	65.5	63.6	62.1	69.8

Note:
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Mission Directorate:	Science
Theme:	Astrophysics
Program:	Exoplanet Exploration

Program Overview

Today humankind stands on the threshold of a voyage of unprecedented scope and ambition, promising insight into one of the most timeless questions. Are we alone? Is Earth unique, or are planets like ours common? One of the most exciting new fields of research within the NASA Astrophysics portfolio is the search for planets, particularly Earth-like planets, around other stars. During the last 15 years, astronomers have discovered over 500 planets orbiting nearby stars. Most of these planets are gas giants, similar in size to the four outer planets in this solar system, and orbit much closer to their parent stars than do the giant planets in this system. NASA's Exoplanet Exploration Program is taking the first steps along a path of discovery that will ultimately lead to a point where scientists can directly study the atmospheres and surface features of habitable, rocky planets like Earth around other stars in the solar neighborhood.

To date, most of the known extrasolar planets, or simply exoplanets, have been discovered with ground-based telescopes. However, the 2009 launch of NASA's Kepler mission (the Agency's first mission dedicated to the study of extrasolar planets) has ushered in a new chapter in the search for planets around other stars. From its unique vantage point of space, Kepler is capable of detecting much smaller planets than are possible with even the most powerful ground based telescopes. Kepler has already shown us that small planets are more abundant than giant planets. Within two years of launch, Kepler will have doubled the number of known exoplanets, including many rocky planets only a few times larger than Earth. By the end of its prime mission, Kepler will enable the first measurements of just how common habitable, Earth-sized planets are in the galaxy.

However, Kepler is just the first component of NASA's Exoplanet Exploration strategy. The technique that Kepler uses to detect exoplanets is most sensitive to large planets on small orbits around their host stars. Noting this measurement bias, the NWNH decadal survey included an exoplanet search using a complimentary detection technique "microlensing" as one of the key components in the science program of its top, large space mission recommendation: the Wide-Field InfraRed Survey Telescope (WFIRST). The microlensing technique is sensitive to small, rocky planets on larger orbits. Thus, together with the Kepler results, WFIRST will give us a clear view of how planetary systems are formed and evolve, and a much clearer understanding of the frequency of habitable, Earth-sized planets in the galaxy.

The ultimate goal for NASA's Exoplanet Exploration Program, as articulated in the decadal survey, is a flagship "New Worlds Mission" that will be capable of imaging and spectroscopy of rocky planets in the habitable zones of stars in the solar neighborhood. This is the mission that will allow NASA to take the pivotal step from identifying an exoplanet as Earth-sized, to determining whether it is truly Earth-like, and possibly even if it bears the fingerprints of life. Recognizing that such an ambitious goal presents numerous significant technological challenges, the decadal survey made "New Worlds Technology Development" its top priority medium-class, space project for the decade. Consequently, an important component of the Exoplanet Exploration effort will be a robust technology development program focused on technologies that feed into the candidate architectures for a future direct-detection mission, and, ultimately, the design and implementation of that mission.

For more information, please see: http://exep.jpl.nasa.gov/.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Exoplanet Exploration

Plans For FY 2012

The Exoplanet Exploration Program will continue the Technology Development for Exoplanet mission's activity to support the development of technologies that feed into candidate architectures for a future direct-detection mission, as recommended by the decadal survey.

Keck Interferometer (KI) will be in its final year of NASA-supported operation, providing U.S. astronomers with access to this unique observational facility in support of NASA astrophysics science goals.
Kepler will be in the third year of operations. The science team will continue to analyze mission data, conduct follow-up observations, and report results in the scientific literature and to the public as they become available.

The Large Binocular Telescope Interferometer will complete integration and testing, and will begin key science operations.

Project Descriptions and Explanation of Changes

Other Missions and Data Analysis

This line item contains the following projects:

- Kepler, launched in March 2009, is specifically designed to survey the distant stars in this region of the Milky Way galaxy to detect and characterize rocky planets in or near the "habitable zone" of their host star. The habitable zone encompasses the distances from a star where liquid water can exist on a planet's surface. As time progresses, smaller and smaller planets with longer and longer orbital periods will begin to emerge from the data.

- Keck Operations is the NASA portion of the Keck Observatory partnership. NASA uses its share of observing time in support of all Astrophysics science programs: Exoplanet Exploration, Cosmic Origins and POCS. Observing time is competed, selected, and managed by the NASA Exoplanet Science Institute. A significant portion of the NASA Keck competed time has been awarded to Keper follow-up observations on potential planet candidates and radio-velocity observations for new exoplanet discoveries.

- The KI is an instrument that connects the two Keck 10-meter telescopes as if they were pieces of a single, 85-meter telescope. With the KI, astronomers are able to study the origins of stars and galaxies, emissions from faint dust clouds around other stars, and the dust and planetary systems around nearby stars. NASA support for the KI has been extended into FY 2012 to allow for a smooth transition of operations from NASA to the California Association for Research in Astronomy (CARA).

- Exoplanet Exploration SR&T supports the prestigious Sagan Postdoctoral Fellowships, program-specific scientific research, and technology development activities that support and enable future Exoplanet Exploration missions. The activities include maintaining a wide-field infrared imaging and spectroscopy capability relevant to the recommended The Wide-Field Infrared Survey Telescope mission and a New Worlds technology initiative. The objective of the latter of these efforts, as recommended in the 2010 decadal survey, is to achieve a level of maturity in the associated technologies sufficient to select the most promising architecture by the middle of the coming decade; focus subsequent technology investments on that architecture; and development of a robust mission concept by the end of the decade.

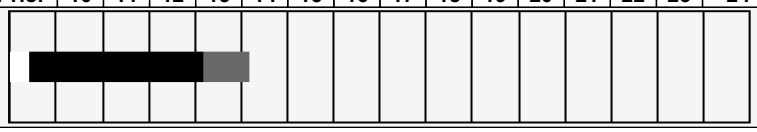
- Exoplanet Exploration Program management provides programmatic, technical, and business management, as well as program science leadership and coordination for education and public outreach products and services.

- Exoplanet Exploration Future missions funding has been moved to support future Astrophysics Explorer missions and to the ExEP SR&T activities. The 2010 decadal survey did not prioritize the Space Interferometry Mission, so NASA support for that mission has been discontinued.

- The LBTI is the NASA portion of the Large Binocular Telescope (LBT) partnership. The instrument is currently under development, and will be ready for full science operations in FY 2012. LBTI will study the formation of solar systems and will be capable of directly detecting giant planets outside this solar system. The key science program of LBTI is to determine the amount of dust that is found in nearby planetary systems. This is an important factor to take into consideration for the development of a direct detection mission, one of the primary challenges identified in the astronomy and astrophysics 2010 decadal survey. Development and operation of this instrument have been funded through FY 2015.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Exoplanet Exploration

Implementation Schedule

Project	Schedule by Fiscal Year															Phase Dates		
	Prior	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		Beg	End
Kepler																	Tech		
																	Form	Dec-01	May-05
																	Dev	May-05	Mar-09
																	Ops	Mar-09	Nov-12
																	Res	Nov-12	Nov-13

Tech & Adv Concepts (Tech)
Formulation (Form)
Development (Dev)
Operations (Ops)
Research (Res)
Represents a period of no activity for the Project

Program Management

JPL is responsible for program management.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Kepler	ARC	ARC	None

Acquisition Strategy

No competitive acquisitions are currently planned.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	Exoplanet Task Force	01/2008	Determine planet-finding research and technology approach and prioritization leading up to the next decadal survey. Report and recommended strategy published and sent to respective agencies. For more information, please see: http://nasascience.nasa.gov/about-us/NAC-subcommittees/nac-documents/2008-01_APS_ExoPTF.pdf.	N/A

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer

FY 2012 Budget Request

Budget Authority ($ millions)	FY 2010	Ann CR. FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
FY 2012 President's Budget Request	**113.5**	**-**	**107.8**	**110.9**	**123.7**	**128.7**	**152.0**
Nuclear Spectroscopic Telescope Array (NuStar)	56.2	-	11.4	4.0	1.1	0.0	0.0
Gravity and Extreme Magnetism	3.1	-	69.4	41.0	20.8	1.4	0.0
Other Missions and Data Analysis	54.2	-	27.0	65.9	101.8	127.3	152.0

Note:
The FY 2011 appropriation for NASA was not enacted at the time that the FY 2012 Request was prepared; therefore, NASA is operating under a Continuing Resolution (P.L. 111-242, as amended). Amounts in the "Ann. CR FY 2011" column reflect the annualized level provided by the Continuing Resolution.

In accordance with the President's proposal to implement a five-year non-security discretionary spending freeze, budget figures shown for years after FY 2012 are notional and do not represent policy. Funding decisions will be made on a year-by-year basis.

In FY 2012 through FY 2016, civil service labor and expenses (CSLE) funds are administered within a single consolidated account in each of the appropriations, and not allocated within the project amounts shown above. The allocation to each project is reflected in the summary budget table included in the beginning of this budget request, which provides a full cost view. In FY 2010 and FY 2011, amounts are presented in full cost.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer

Program Overview

The aim of the Explorers Program is to provide frequent flight opportunities for world-class scientific investigations from space utilizing innovative, streamlined and efficient management approaches within the heliophysics and astrophysics science areas. Explorer missions are highly responsive to new knowledge, new technology, and updated scientific priorities by launching smaller missions that can be conceived and executed in a relatively short development cycle. Priorities are based on an open competition of concepts solicited from the scientific community. The program also enables participation in missions of opportunity provided by other U.S. or international agencies. The program emphasizes missions that can be accomplished under the control of the scientific research community within constrained mission life cycle costs. The program also seeks to enhance public awareness of space science by incorporating educational and public outreach activities into each mission.

The standard Explorer (EX) missions are investigations characterized by definition, development, and mission operations and data analysis costs up to $200 million, not including launch services. Small Explorers (SMEX) may cost up to $120 million, not including launch services. Explorer Missions of Opportunity (MOs) have a total NASA cost of under $55 million and may be of several types. The most common are partner MOs, investigations characterized by being part of a non-NASA space mission (of any size). These missions are conducted on a no-exchange-of-funds basis with the organization sponsoring the mission. Other possible types are new science missions using existing spacecraft, and small complete missions. NASA intends to solicit proposals for missions of opportunity with each Announcement of Opportunity issued for EX and SMEX investigations, and perhaps more frequently. Beginning in FY 2012, funding for future Explorer missions (formerly managed in the Heliophysics Theme) is being split into two pieces. Astrophysics Theme will continue to coordinate with Heliophysics theme and the Explorer Program office at GSFC regarding mission management and future solicitations, but will have responsibility beginning in 2012 for managing its own budgetary resources for future selections to enable a diverse portfolio of stand-alone missions and MO. This split will help enable the implementation of the decadal survey's recommendation to augment the Explorer Program to provide more opportunities to respond rapidly to new science opportunities.

For more information, please see Explorer Program at explorers.gsfc.nasa.gov/missions.html.

Currently, there are two Explorer missions in development: NuSTAR, and the Astro-H Soft X-ray Spectrometer. GEMS is in formulation. Four previously launched Explorer missions are also supported in this program, as they continue to produce world-class science in their extended mission phases.

Plans For FY 2012

NuSTAR will be completing observatory integration and beginning integration to the Pegasus XL launch vehicle in preparation for a February 2012 launch from Kwajalein Island in the Republic of the Marshall Islands.

The high-resolution SXS instrument for the JAXA-led Astro-H mission will be in the final stages of integration and test during FY 2012. Two major flight model subsystems (the x-ray telescope optics and the electrical harness) will be delivered to Japan during FY 2012 in order to facilitate early integration and test of those subsystems. The completed SXS instrument will be shipped to Japan for spacecraft integration and test either late in FY 2012 or early in FY 2013.

The Gravity and Extreme Magnetism Critical Design Review is scheduled in March 2012.

Project Descriptions and Explanation of Changes

Nuclear Spectroscopic Telescope Array (NuSTAR)

NuSTAR, currently in development, is planned for launch in February 2012. NuSTAR will provide a greater capability for using high-energy X-rays to detect black holes than any currently existing instrument. NuSTAR has been designed to answer fundamental questions about the universe. How are black holes distributed through the cosmos? How were the elements of the universe created? What powers the most extreme active galaxies? This mission will expand the ability to understand the origin of cosmic rays and help predict the destinies of stars and galaxies.

Astro-H SXS

Astro-H SXS is a mission of opportunity, currently in development, in which NASA will provide the SXS instrument. Astro-H SXS is scheduled for a 2014 launch onboard the Japanese Astro-H spacecraft. The observatory will carry a suite of four science instruments spanning virtually the entire X-ray energy band. The SXS instrument is a cryogenically cooled high-resolution X-ray spectrometer that will allow the most detailed studies of the high-energy spectra of a wide range of astronomical systems from nearby stars to distant active galaxies. Utilizing this unprecedented capability, the mission will conduct a number of fundamental studies, including: tracing the growth history of the largest structures in the universe; obtaining insights into the behavior of material in extreme gravitational fields; determining the spin of black holes; probing shock acceleration structures in clusters of galaxies; and investigating the detailed physics of jets.

Additional funding has been added in FY 2011 through 2014 based on a 70 percent joint cost and schedule analysis in order to assure adequate reserves through launch, consistent with the decision made by SMD at confirmation review.

Gravity and Extreme Magnetism SMEX (GEMS)

The GEMS mission is currently in formulation and will seek approval to enter development during FY 2011. GEMS will use an X-ray telescope to explore the shape of space that has been distorted by a spinning black hole's gravity. It will probe the structure and effects of the formidable magnetic field around magnetars, dead stars with magnetic fields trillions of times stronger than Earth's.

Funding has been increased in FY 2011 and 2012 (and reduced in the out years) in order to accommodate increased early payments for the launch vehicle.

Other Missions and Data Analysis

Included in this line item are:

- A Future Astrophysics Explorer Missions budget has been created in response to the astronomy and astrophysics 2010 decadal survey recommendation to accelerate the launch rate of Astrophysics Explorer missions. This funding, combined with a portion of future Explorer mission funding previously held in the Heliophysics Theme, will allow for more frequent selection and launch of Astrophysics Explorer missions and MOs. This will enable a rapid response to new discoveries and provide platforms for targeted investigations essential to the breadth of the Astrophysics program. Astrophysics will continue to coordinate with the Heliophysics Theme and Explorer Program office at GSFC regarding mission management and future solicitations, but will have responsibility beginning in 2012 for managing its own budgetary resources for future selections.

- The Wide-field Infrared Survey Explorer (WISE) provided an all-sky survey of galaxies in the infrared light spectrum. During its six-month mission, WISE mapped the sky in infrared light, searching for the nearest and coolest stars, the origins of stellar and planetary systems, and the most luminous galaxies in the universe. WISE's infrared survey provided an essential catalog for JWST science program planning.

- Swift is a multi-wavelength space-based observatory in extended operations phase that studies the position, brightness, and physical properties of gamma-ray bursts. Within seconds of detecting a burst, Swift relays the location of a burst to ground stations. This allows both ground-based and space-based telescopes around the world to observe the burst's afterglow. As a result of the Senior Review 2010, Swift has received additional funding to extend its operational life. Budget planning for Swift reflects reductions to some operating missions and plans to focus Swift observing campaigns on the highest impact activities.

- WMAP studies the early universe by measuring the cosmic microwave background radiation over the full sky. WMAP produced the earliest "baby picture" of the universe, showing temperature variation of microwave light 379,000 years after the Big Bang, over 13 billion years ago. As a result of the Senior Review 2010, WMAP has received additional funding to extend its operational life.

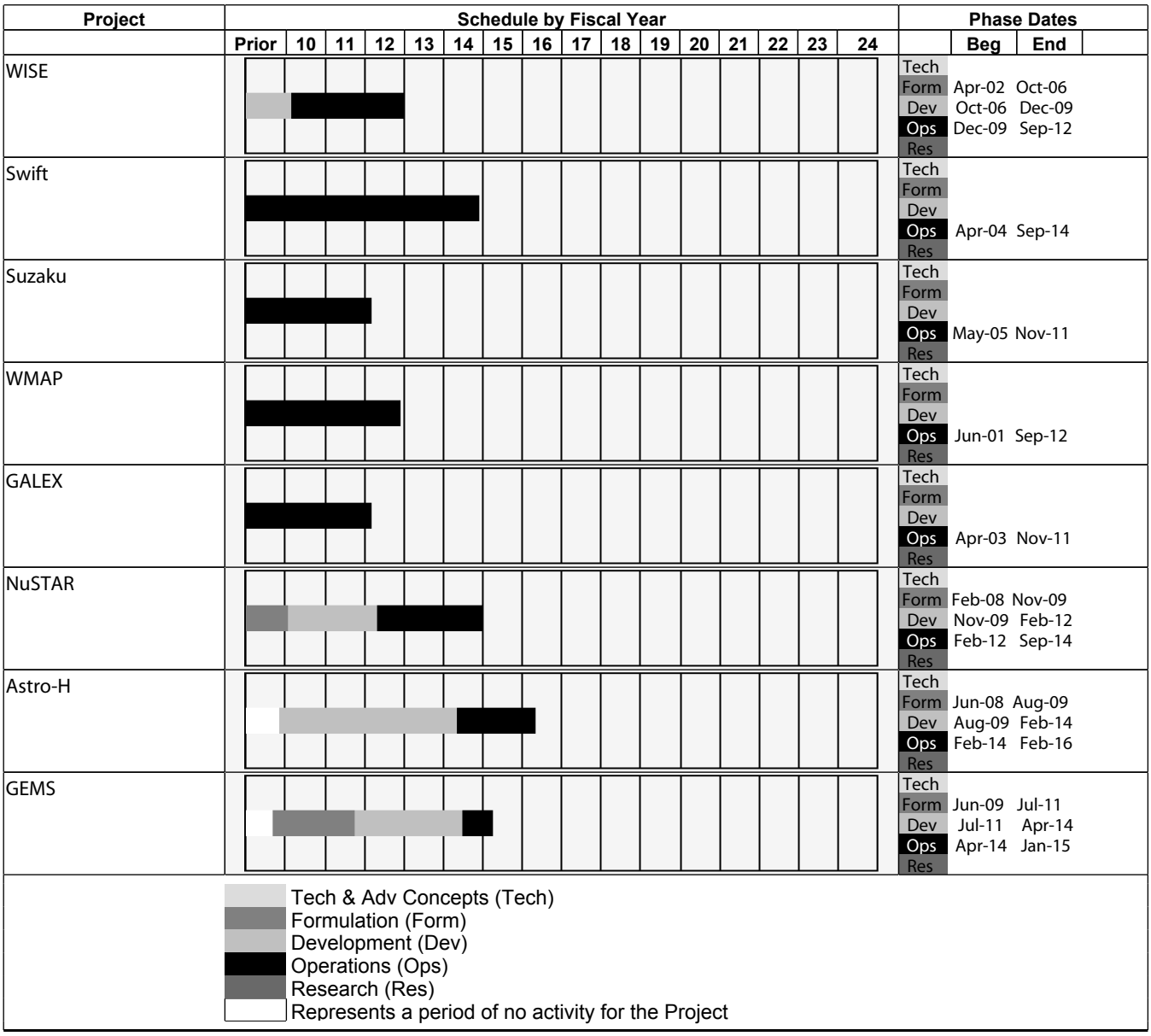
- The Galaxy Evolution Explorer (GALEX) and Suzaku missions will be terminated in FY 2011 and will complete any necessary mission closeout activities in FY 2012.

Program Commitments

Commitment/Output FY 2012	Program/Project	Changes from FY 2011 PB Request
Complete the NuSTAR Launch Readiness Review.	NuSTAR	

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer

Implementation Schedule



Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer

Program Management

Management of the Astrophysics Explorer Program is assigned to GSFC.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
WISE	GSFC	JPL	None
NuSTAR	GSFC	JPL	None
Astro-H	GSFC	GSFC	Japan (JAXA)
Swift	GSFC	N/A	None
WMAP	GSFC	N/A	None
GEMS	GSFC	GSFC	None

Acquisition Strategy

Explorer projects are selected through competitive Announcements of Opportunity from which multiple investigations are selected for initial concept studies. This is followed by a competitive down-select to proceed to the next stage of formulation. Investigations are selected to proceed from one phase to the next through execution of contract options, based on successful technical, cost, and schedule performance in the previous phases.

The most recent Explorer Announcement of Opportunity was released on November 1, 2010 with proposals due on February 16, 2011, and final selections expected in late 2012 or early 2013. From this solicitation, NASA expects that at least one full Explorer mission will be selected to proceed into Phase B and subsequent mission phases. The proposed Astrophysics Explorers budget is intended to support selection of one full mission and one or more missions of opportunity.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer
Project In Development:	Nuclear Spectroscopic Telescope Array

FY 2012 Budget Request

Budget Authority ($ millions)	Prior	FY 2010	Ann CR. FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
FY 2012 President's Budget Request	**55.4**	**56.2**	**-**	**11.4**	**4.0**	**1.1**	**0.0**	**0.0**

Note: The FY 2011 LCC number in the table above is overstated by $3.7 million due to the difference between the FY 2010 enacted bill and the pending FY 2012 Passback. Assuming approval of the initial operating plan, the estimated life cycle cost will be $160.6 million, and the estimated development cost will be $109.9 million.

The FY 2011 appropriation for NASA was not enacted at the time that the FY 2012 Request was preparedFor the FY 2012 Budget Request, project life cycle estimates, required to meet the requirements of section 103 of the NASA Authorization Act of 2005 (P.L. 109-155; 42 U.S.C. 16613), have been consolidated in the Management and Performance Section of this document. This consolidation provides for a comparative analysis across projects, and the inclusion of corrective action plans for the projects that have exceeded their original baseline estimates by greater than fifteen percent.

; therefore, NASA is operating under a Continuing Resolution (P.L. 111-242, as amended). Amounts in the "Ann. CR FY 2011" column reflect the annualized level provided by the Continuing Resolution.

In accordance with the President's proposal to implement a five-year non-security discretionary spending freeze, budget figures shown for years after FY 2012 are notional and do not represent policy. Funding decisions will be made on a year-by-year basis.

In FY 2012 through FY 2016, civil service labor and expenses (CSLE) funds are administered within a single consolidated account in each of the appropriations, and not allocated within the project amounts shown above. The allocation to each project is reflected in the summary budget table included in the beginning of this budget request, which provides a full cost view. In FY 2010 and FY 2011, amounts are presented in full cost.

Explanation of Project Changes

NuSTAR launch has been delayed by one month (to February 2012) due to potential conflicts at the launch site. Funding has been increased slightly for education and public outreach activities.

NuSTAR continues to reach its milestones and in FY 2012 will be completing observatory integration and beginning integration to the Pegasus XL launch vehicle in preparation for a subsequent February 2012 air launch from Kwajalein Island in the Republic of the Marshall Islands.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer
Project In Development:	Nuclear Spectroscopic Telescope Array

Project Purpose

The NuSTAR mission will observe the universe at high X-ray energy levels. By focusing higher energy X-rays, NuSTAR will start to answer several fundamental questions about the universe. How are black holes distributed through the cosmos? How were heavy elements forged in the explosions of massive stars? What powers the most extreme active galaxies?

NuSTAR's primary science goal is to make the first deep observations of regions of the sky in the high energy X-ray band in order to locate massive black holes in other galaxies; locate and examine the remnants of collapsed stars in this galaxy; observe selected very high energy gamma-ray sources; and observe any supernovae of opportunity in the local group of galaxies. NuSTAR's key science products will be sensitive high-energy X-ray survey maps of the celestial sky that will guide the X-ray astronomy community research for several years to come. In addition to its core science program, NuSTAR will offer opportunities for a broad range of science investigations, ranging from probing cosmic ray origins to studying the extreme physics around collapsed stars to mapping microflares on the surface of the Sun. NuSTAR will perform follow-up observations to discoveries made by Chandra and Spitzer, and will team with Fermi to make simultaneous observations.

For more information see: http://www.nustar.caltech.edu/.

Project Parameters

NuSTAR will image the sky in the high- energy X-ray band (6-79 KeV) and the spacecraft will be three -axis stabilized. The primary science instruments will be two identical focusing X-ray telescopes which utilize an extendable 10-meter mast. The launch vehicle will be a Pegasus XL.

Project Commitments

NuSTAR will be launched in February 2012 into a 550 by 600 kilometer orbit around Earth, with an orbital inclination currently planned for six degrees. The prime operations phase is two years.

Project Element	Provider	Description	FY 2011 PB Request	FY 2012 PB Request
Spacecraft	Orbital Sciences Corporation	Spacecraft design, fabrication and testing.	N/A	Same
Mission operations, focal plane assembly and instrument electronics	University of California, Berkeley	Aperture stop, active shield module and mechanical enclosures	N/A	Same
X-ray optics	Columbia University, GSFC and the Danish Technical University	Overall optics assembly management and manufacturing	N/A	Same
Mast, canister and instrument structure	ATK	Delivery of mast, canister and instrument structure for the spacecraft	N/A	Same

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer
Project In Development:	Nuclear Spectroscopic Telescope Array

Schedule Commitments

NuSTAR was authorized for mission re-start in September 2007 and was authorized to proceed into Phase B in January 2008. Confirmation to proceed into Phase C (implementation) was approved in August 2009.

Milestone Name	Confirmation Baseline	FY 2011 PB Request	FY 2012 PB Request
Development			
Preliminary Design Review	June 2009	same	same
Confirmation Review	August 2009	same	same
Critical Design Review	February 2010	same	same
Launch	January 2012	January 2012	February 2012

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer
Project In Development:	Nuclear Spectroscopic Telescope Array

Project Management

JPL is responsible for NuSTAR project management. The principal investigator at the California Institute of Technology is responsible for mission science.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Mission Science	JPL	N/A	N/A
Launch Vehicle	KSC	N/A	N/A
Spacecraft, instruments, mast, optics	JPL	GSFC	N/A

Acquisition Strategy

NuSTAR was selected via a NASA Explorers Announcement of Opportunity. The spacecraft is being developed by Orbital Sciences Corporation in Dulles, Virginia. The X-ray optics are being developed by Columbia University in New York City, New York; GSFC; and the Danish Technical University, Denmark. Launch vehicle acquisition is through Kennedy Space Center (KSC).

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SRB	6/2009	Preliminary Design Review; received authority to enter Phase C	N/A
Performance	SRB	2/2010	Critical Design Review. NuSTAR design was deemed sufficiently mature to proceed with full-scale fabrication, assembly, integration and testing.	N/A
Performance	SRB	N/A	System Integration Review (SIR). Evaluates the readiness of the project to start flight assembly, test, and integration.	01/2011
Performance	SRB	N/A	Flight Readiness Review (FRR). Determines the overall system readiness for a safe and successful flight.	1/2012

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Observatory Mass Margin	The combined mass of the spacecraft and instrument forces design changes that tax project programmatic resources.	Remove shells from each coated mirror. This would free up about 6-10kg from the instrument.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer
Project In Formulation:	Gravity and Extreme Magnetism (SMEX 13)

FY 2012 Budget Request

Budget Authority ($ millions)	FY 2010	Ann CR. FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
FY 2012 President's Budget Request	**3.1**	**-**	**69.4**	**41.0**	**20.8**	**1.4**	**0.0**

Note:

The FY 2011 appropriation for NASA was not enacted at the time that the FY 2012 Request was prepared; therefore, NASA is operating under a Continuing Resolution (P.L. 111-242, as amended). Amounts in the "Ann. CR FY 2011" column reflect the annualized level provided by the Continuing Resolution.

In accordance with the President's proposal to implement a five-year non-security discretionary spending freeze, budget figures shown for years after FY 2012 are notional and do not represent policy. Funding decisions will be made on a year-by-year basis.

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Project Purpose

GEMS will use an X-ray telescope to explore the shape of space that has been distorted by a spinning black hole's gravity, and probe the structure and effects of the formidable magnetic field around magnetars--dead stars with magnetic fields trillions of times stronger than that of Earth.

Current missions cannot accomplish the goals of GEMS because they are not capable of the required angular resolution or, in the case of magnetic field imaging, because magnetic fields are invisible. GEMS will use a new technique to accomplish what has been impossible until now. It will build up a picture indirectly by measuring the polarization of X-rays emitted from these violent regions. This will open new discovery space because GEMS is orders of magnitude more sensitive than previous X-ray polarization experiments.

GEMS will answer some of the most exciting and fundamental questions in astrophysics. How does the spin of a black hole warp space time? What powers pulsars and magnetars? How are cosmic rays accelerated in supernova remnants?

GEMS will be better able to tell the shapes of the X-ray-emitting matter trapped near black holes than existing missions. In particular, GEMS will be able to detect whether matter around a black hole is confined to a flat disk or puffed into a sphere or squirting out in a jet. Since X-rays are polarized by the space swirling around a spinning black hole, GEMS also provides a method of determining black hole spin independent of other techniques.

Project Preliminary Parameters

The nominal science mission is about one year in duration. The X-ray Polarimeter Instrument (XPI) consists of two or three identical, co-aligned telescopes, and will be sensitive from two to 10 kev to polarization amplitude and angle. It's orbit will be 575 kilometer with a 28.5degree inclination. It will have alaunch mass of 267 kilograms, solar arrays at 637 west, articulated, and stabilization on a three -axis.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer
Project In Formulation:	Gravity and Extreme Magnetism (SMEX 13)

Estimated Project Deliverables

GEMS will study 23 targets including stellar-mass, black holes, seyfert galaxies and quasars, blazars, neutron star pulsars, shell supernovae remnants, and pulsar wind nebulae. The GEMS satellite will be the first observatory to systematically measure X-ray polarization, encoding information about the structure of cosmic sources. Polarization measurements will allow scientists to study scattering magnetic fields and strong gravitational fields.

Project Element	Provider	Description	FY 2011 PB Request	FY 2012 PB Request
Spacecraft	Orbital	Small spacecraft based on reusable design	Same	Same
Instrument Payload	GSFC	XPI	Same	Same
Launch Vehicle	TBD	Small Class	Same	Same

Estimated Project Schedule

The GEMS project was selected for formulation in October 2009.

Milestone Name	Formulation Agreement Estimate	FY 2011 PB Request	FY 2012 PB Request
Formulation			
SRR (Mission)	June 2010	June 2010	October 2010
KDP-C	July 2011	July 2011	August 2011
Launch	April 2014	Same	Same

Project Management

GEMS is part of the Explorers Program managed by GSFC.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Spacecraft	GSFC	None	N/A
X-ray Polarimeter Instrument (XPI)	GSFC	GSFC	N/A
Launch Vehicle	KSC	None	N/A

Acquisition Strategy

The largest portion of the overall project effort has been awarded to Orbital Sciences Corporation. In Phases B/C/D/E, the contract with Orbital Sciences Corporation is of the cost-plus-award fee type.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer
Project In Formulation:	Gravity and Extreme Magnetism (SMEX 13)

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SRB	N/A	Preliminary Design Review; determine if the project is ready to proceed into development	07/2011

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Late Polarimeter Delivery to Instrument I&T	If the Polarimeter does not meet the delivery date to the Instrument I&T, then the mission schedule will be impacted.	The project plans to develop an Engineering Test Unit of the Polarimeter to mature the technology and test before building the flight unit.